Article:
Zusman, O, Bebb, O, Hall, M orcid.org/0000-0003-1246-2627 et al. (7 more authors) (2019) International comparison of acute myocardial infarction care and outcomes using quality indicators. Heart, 105 (11). pp. 820-825. ISSN 1355-6037

https://doi.org/10.1136/heartjnl-2018-314197

Acute myocardial infarction: a comparison of care and outcomes using quality indicators in Israel and the UK

Oren Zusman [a,b], Owen Bebb[c], Marlous Hall[c], Tatendashe B Dondo[c], Adam Timmis[d], Francois Schiele[e], Keith AA Fox[f], Ran Kornowski [a,b], Chris P Gale[c], Zaza Iakobishvili[a,b,g]

[a] Department of Cardiology, Rabin Medical Center, Petah Tikva

[b] Sackler Faculty of Medicine, Tel Aviv University, Israel

[c] Leeds Institute of Cardiovascular and Metabolic Medicine, University of Leeds, Leeds, UK

[d] Barts Health Centre London, NIHR Cardiovascular Biomedical Research Unit, London, UK

[e] Department of Cardiology, University Hospital of Besancon, EA3920 University of Franche-Comté, France

[f] Centre for Cardiovascular Science, University of Edinburgh, Edinburgh, UK.

[g] Department of Community Cardiology, Tel Aviv Jaffa District, Clalit Health Services

Word count (excl. references): 2911

Abstract

Objective

To compare temporal changes in European Society of Cardiology (ESC) acute myocardial infarction (AMI) quality indicator (QI) attainment in the United Kingdom (UK) and Israel.

Methods

Data cross walking using information from the Myocardial Ischaemia National Audit Project (MINAP) and the Acute Coronary Syndrome in Israel Survey (ACSIS) for matching 2 month periods in 2006, 2010 and 2013 was used to compare country-specific attainment of 14 ESC AMI QIs.

Results

Patients in the UK (n=17,068) compared with Israel (n=5,647) were older, more likely to be women, and had less diabetes, dyslipidemia and heart failure. Baseline ischaemic risk was lower in Israel than the UK (GRACE risk 110.5 vs. 121.0). Overall, rates of coronary angiography (87.6% vs. 64.8%) and percutaneous coronary intervention (70.3% vs. 41.0%) were higher in Israel compared with the UK. Composite QI performance increased more in the UK (1.0% to 86.0%) than Israel (70.2% to 78.0%). Mortality rates at 30 days declined in each country, with lower rates in Israel in 2013 (4.2% vs. 7.6%). Composite QI adherence adjusted for GRACE risk score was inversely associated with 30-day mortality (OR 0.95, CI 0.95-0.97, $p<0.001$).

Conclusions

International comparisons of guideline recommended AMI care and outcomes can be quantified using the ESC AMI QIs. International implementation of the ESC AMI QIs may reveal country-specific opportunities for improved healthcare delivery.

What is already known about this subject? The European Society of Cardiology has developed a suite of quality indicators for acute myocardial infarction. Increased quality indicator attainment for acute myocardial infarction is associated with decreased mortality.

What does this study add? The European Society of Cardiology quality indicators for acute myocardial infarction may be used in nationwide continuous and snapshot registries to investigate between and within country care and outcomes for acute myocardial infraction

How might this impact on clinical practice? Nationwide cardiovascular data interrogation may enable health systems to ascertain where quality improvements may be made for acute myocardial infarction such that premature death from cardiovascular disease is reduced.

Introduction

The evaluation of quality of care that extends beyond clinical outcomes is of growing interest to hospitals, physicians, and patients[1,2]. Evidence suggests that measuring and reporting healthcare is associated with clinical improvements[3]. With this in mind, metrics have been developed by the American College of Cardiology and American Heart Association (ACC/AHA) to assess care quality and to serve as targets for quality improvement initiatives[4,5]. In 2016, The European Society of Cardiology (ESC) proposed 20 quality indicators (QIs) for acute myocardial infarction (AMI), based upon the ESC guidelines[6,7], spanning seven domains of care[8]. These QIs have been externally validated in national clinical registries of AMI and demonstrated a significant inverse association with mortality at 30 days and 3 years[9,10].

International consensus recommends the routine recording of demographic, treatments and outcomes data for AMI[5,6] . Accordingly, a number of countries participate in the continuous or snapshot data collection of AMI hospitalizations into clinical registries, including the United Kingdom (UK) Myocardial Ischaemia National Audit Project (MINAP)[11], and the Acute Coronary Syndrome in Israel Survey (ACSIS)[12], among others[13,14]. Although international comparisons have revealed differences in early mortality and between-center variation in the provision of care following AMI, there are no studies of the temporal changes in care and outcomes between countries as measured according to published AMI QIs. This knowledge gap is important given the fact that AMI performance metrics are associated with delays to implementation of care, and potentially avoidable

deaths[9,10,15,16]. We therefore used data from the MINAP and ACSIS national AMI registries to assess the provision of care according to the ESC AMI QIs between 2006 and 2013.

Methods

ACSIS

ACSIS is a national acute coronary syndrome snapshot survey conducted in all 25 cardiology departments in Israel since 1992 over a two-month period, every two to three years[12]. ACSIS prospectively collects data pertaining to all acute coronary syndrome hospitalizations using a pre-specified case record form. The forms, completed by unit physicians, are then transferred to a central database. The survey is governed and coordinated by the Working Group on Acute Cardiovascular Care, part of the Israeli Heart Society, in participation with the Israeli Association for Cardiovascular Trials (IACT). The data storage, maintenance and processing is performed by the IACT, which also reviews documents to ensure data validity. Mortality data during hospitalization, at 30 days, and at 1-year are determined for all patients from hospital charts and by matching identification numbers of patients with the Israeli National Population Register.

MINAP

MINAP is a comprehensive registry of ACS hospitalisations occurring in all acute National Health Service hospitals in England and Wales and is mandated by the UK Department of Health. Data regarding patient demographics, treatments and outcomes

are collected for each patient, prior to secure electronic transfer to a central database under the auspice of the National Institute for Cardiovascular Outcomes Research[11,17]. There, data are linked to the Office for National Statistics for vital status and anonymized before distribution for the purposes of service evaluation and research. MINAP undergoes annual data validation by participating hospitals and the dataset is reviewed biennially. Comparison of key elements of the two registries and their host health systems is provided in the supplementary appendix.

Analytical cohorts

For MINAP, the analytical cohort (n=17,518) was drawn from all MINAP patients aged ≥18 years with a discharge diagnosis of AMI (n=733,864) between 2003 and 2013 and, by means of data cross walking (i.e., ensuring good mapping of cohorts), cases aligned to the ACSIS snapshot time periods (years 2006, 2010 and 2013) were selected. For both cohorts, cases with missing mortality data were excluded (Figure 1). Other than that there were no excluded patients. No data were transferred between countries.

Quality indicators

Full details of the ESC AMI QIs are provided in supplementary table S1[8]. Briefly, each of the 20 ESC AMI QIs was mapped to the respective registry's data fields to determine those available for derivation. Patient eligibility for care was derived according to the ESC AMI QI definitions[8]. Patients who were recorded as having declined treatment or in whom treatment was deemed inappropriate by treating physicians were considered ineligible, as were those with a documented contraindication for specific treatments, as defined in each country. Patients with

missing data were excluded from corresponding QIs. Denominators for each QI were calculated separately with the appropriate patient population such that, for example, in-hospital deaths were not included in QI 4 and 5 which concern medications prescribed at time of discharge from hospital.

Domain 7 of the ESC QIs assesses quality of care by means of composite scores. These were calculated using both an opportunity and all-or-none methodology. The opportunity based score was calculated using an equal weight method based on the number of times particular care processes were performed (numerator) divided by the number of chances a patient had to receive that care (denominator). Patients achieved the composite score whether the received all of the care interventions they were eligible for. The opportunity composite score originally consisted of 12 measures, however, MINAP data only allows assessment of nine measures combined using an equal weight method[9]. Quality indicator inclusion and qualification is shown in Supplementary Table S2.

Statistical methods

Patient baseline characteristics were described using numbers and percentages for categorical data, and medians and inter quartile ranges (IQR) or means and standard deviations (SD) for continuous non-normally and normally distributed data respectively. To estimate the Global Registry of Acute Coronary Events (GRACE) risk score adjusted 30-day mortality, we used the predicted probabilities derived from a logistic regression model where the dependent variable was 30-day mortality and the independent variable was each patient's calculated GRACE risk score. For

MINAP and ACSIS, the GRACE score was calculated using the mini-GRACE methodology which has been previously validated with MINAP data[18]. Validation of the ACSIS cohort is presented in the supplement. This method allows for the substitution of 'use of loop diuretic' for Killip class and chronic renal failure in lieu of creatinine concentration for those records with missing information. Specifically, for ACSIS, GRACE scores were recalculated from the raw data to ensure compatibility with the MINAP GRACE risk score method. A logistic regression model was fitted to quantify the association between each QI and 30-day mortality. In line with previous research, for the composite QI, performance was split into 3 categories: (1) <40% of eligible interventions received, (2) ≥40% to <80% of eligible intervention received, and (3) ≥80% of interventions received[9,19,20]. We excluded measures that had ≤30 patients with complete data for either aspect of the QI. Analyses were conducted in parallel without international transfer of analytical cohort data using R version 2.3 (R Core Team, Vienna, Austria) and Stata MP Version 14.0 (StataCorp LP, TX, USA), with statistical significance determined at 5%.

Ethics

Data collection for all ACSIS surveys was approved at each hospital by the local institutional Ethics Review Committee. For this study, fully anonymized data were used, and no ethics approval was required. MINAP data used for the study were fully anonymized and, as such, ethical approval was not required under NHS research governance arrangements. The National Institute for Cardiovascular Outcomes Research (NICOR) which includes the MINAP database (Ref: NIGB: ECC 1-06 (d)/2011) had support, under section 251 of the National Health Service Act 2006, to

use patient information for medical research without consent. The study was conducted in compliance with the Declaration of Helsinki.

Results

Patient and treatment characteristics

There were 21,829 patients across the comparison periods, comprising 17,068 from the UK (78.2%) and 4,761 from Israel (21.8%). Patients admitted with AMI in the UK were older compared with Israel (mean age 69.3 (SD 13.9) years vs. 63.8 (13.1) years), more frequently were women (33.9% vs. 22.2%), had lower rates of diabetes (19.6% vs. 36.3%), dyslipidemia (33.0% vs. 69.5%), heart failure (5.2% vs. 8.5%) and chronic kidney disease (5.6% vs. 12.9%) (Table 1). In Israel, there were more patients with electrocardiographic ST-segment deviation (69.8% vs. 55%). In Israel, there were 2332 (49%) NSTEMI, compared with 10,567 (60.0%) NSTEMI in the UK.

Whilst the rates of an invasive coronary strategy (coronary angiography (87.6% vs. 64.8%), percutaneous coronary intervention (PCI) (70.3% vs. 41.0%) and coronary artery bypass (CABG) surgery (5.3% vs. 2.0%) were higher between 2006 and 2013 in Israel compared with the UK, the prescription of guideline-indicated medications at the time of hospital discharge (for hospital survivors) varied by country – being higher in the UK for β-blockers (86.5% vs.79.4%) and angiotensin converting enzyme inhibitors (ACEi)/angiotensin receptor blockers (ARB) (84.7% vs. 76.1%).

Ischaemic risk

The GRACE score was lower for patients with AMI in Israel compared with the UK (110.5 vs 121.0). This was driven by lower baseline ischaemic risk for ST-segment elevation myocardial infarction, STEMI (96.6 vs 122.3) rather than non-STEMI (NSTEMI) (123.1 vs. 120.2) in Israel compared with the UK and, in turn, influenced by a higher age for STEMI in the UK than Israel (mean age 65.8 years vs 61.5 years) (Figure 2).

Temporal trends in patient and treatment characteristics

In Israel from 2006 and 2013, there was an increase in the proportion of patients with hypertension (57.1% vs. 65.0%), diabetes (32.3% vs. 39.6%), and dyslipidaemia (69.5% vs. 74.1%), and a decrease in peripheral vascular disease (10.1% vs. 7.9%). Fewer patients presented with ST-segment deviation (72.9% vs. 65.8%) and were more frequently in Killip class I (80.1% vs. 87.2%). The rates of coronary angiography (83.3% vs. 89.7%) and PCI (65.7% vs. 73%) increased from a high baseline in 2006.

In the UK, there was a decline in the proportion of patients with a prior history of AMI (36.4% vs. 32.4%), family history of ischaemic heart disease (33.0% vs. 28.8%) and cerebrovascular disease (9.4% vs. 7.8%), and an increase in dyslipidemia (30.9% vs. 33.2%) and chronic kidney disease (3.6% vs. 6.5%). There was an increase in the proportion of patients presenting to hospital after an out of hospital cardiac arrest (1.7% vs. 2.9%) and fewer patients with ST-segment deviation (58.7% vs. 53.8%). There was an increase in the proportion of patients with a high GRACE risk score (22.8% vs. 26.3%). The rates of coronary angiography more than doubled (37.3% vs.

85.5%) and rates of PCI more than quadrupled (14.4% to 66.0%), both driven by an increase in primary PCI for STEMI (0.6% vs. 56.2% vs 80.3%) and an invasive coronary strategy for NSTEMI (35.9% vs. 63.9% vs. 78.5%).

Quality Indicators

Data cross walking between the two countries found that 14 of the 20 ESC AMI QIs were available for comparison in each country. Centre organization was not calculated as assumed 100% both in ACSIS and MINAP. For QI 2.2c (door-in-door out) the split by year resulted in very small numbers and was omitted. Both MINAP and ACSIS allow the calculation of the GRACE risk score, however, as the QI specifies recording in the medical record, they were calculated as zero. The CRUSADE score is not currently recorded nor can it be calculated in MINAP or ACSIS, so calculated as zero. For QI 5.1 (secondary prevention with high-dose statins), discharge with statins was used for all patients (MINAP) or where not recorded (ACSIS) as surrogate. In addition, information regarding QI 6.1 (patient satisfaction) is not recorded in both registries and was omitted.

In the UK between 2006 and 2013, the time and range of times to achieve arterial access for PPCI was reduced by at least half (80.4 (IQR 135) vs. 40.2 (31) minutes) and compared with Israel where access times and their ranges were stable (70.3 (68) vs. 67.0 (72) minutes). By contrast, in Israel a high proportion of NSTEMI received timely coronary angiography (83.8% in 2013) compared with the UK (64.1% in 2013). The assessment of left ventricular function on discharge was higher in Israel (72.2% in 2013) despite temporal improvements in the UK (50.1% in 2013 vs. 22.1% in 2006). The prescription of $P2Y_{12}$ inhibitors in the UK increased from its

introduction in 2006 (1.1%) to 94.9% of patients discharged with AMI in 2013 and compared with 77.4% in 2006 to 86.3% in Israel for the same period. In 2013, fondaparinux was rarely used in Israel with higher, yet modest, rates of use in the UK (2.4% vs. 49.5%). Healthcare performance as measured by the composite QIs increased in the UK from 46.2% in 2006 to 80.0% in 2013 (7.1, opportunity based score) and from 1.0% in 2006 to 86.0% in 2013 (7.2, all-or-none score), with no change in 7.1 (86.8% vs. 85.9%) and an increase in 7.2 in Israel (70.2% vs. 78.0%). A heat-map figure with performance of selected QI's by registry and year is presented in Figure 3.

Mortality

Crude 30-day and 1 year mortality rates declined more between 2006 and 2013 in the UK than in Israel (30-day: -3.2 vs,-1.6%; 1-year: -11.9% vs. –2.3%), though at the end of the study period were higher in the UK than Israel at 30-days (7.8% vs. 3.8%) and at 1-year (10.1% vs.8.6%). After adjustment for baseline ischaemic (GRACE) risk, 30-day mortality rates decreased equally over the study period in the two countries (-0.6% and -0.5%, respectively), and were higher in the UK compared with Israel in 2013 (7.6% vs. 4.2%).

In Israel, increasing opportunity-based composite QI attainment from low to intermediate to high was associated with decreasing 30-day mortality (61.0% vs. 21.8% vs. 2.0%, $p<0.001$ for difference). Similarly, higher opportunity-based composite QI attainment, was associated with lower GRACE adjusted 30-day mortality (OR 0.95, 95% CI 0.95-0.97, $p <0.001$) with the magnitude and direction of

the effect remaining after further adjustment for year of hospitalisation (OR 0.98, 95% CI 0.97-0.98, p<0.001).

This pattern was mirrored in the UK with a reduction in crude 30-day (43.2% vs. 6.2% vs. 2.9% p<0.001 for low, intermediate and high attainment respectively) and one year mortality (53.8% vs. 17.0% vs 6.4% p<0.001 respectively). Equally, opportunity-based QI attainment was associated with decrease in GRACE adjusted 30-day mortality (OR 0.97, 95% CI 0.96-0.97 p<0.001) which also remained after adjustment for year of hospitalisation (OR 0.97 95% CI 0.95-0.97, p<0.001). Similar results were observed when examining 1-year mortality in 30-day survivors against QI attainment percentage (OR 0.98, 95% CI 0.97-0.98, p<0.001 for both cohorts).

Discussion

In this international study, we used the ESC AMI QIs to compare temporal changes in the delivery of healthcare across Israel and the UK. We found that in Israel patients with AMI tended to be younger, had a lower baseline ischaemic risk, more frequently received an invasive coronary strategy and had lower mortality rates compared with the UK. Even so, we noted a rapid upturn in the UK in the attainment of guideline-indicated care as quantified by the ESC AMI QIs. Moreover, this study provides evidence for the application of the ESC AMI QIs for comparative evaluation of AMI healthcare delivery to highlight where in health systems they may be opportunities for quality improvement and, therefore, improved clinical outcomes for AMI.

We found that adherence to the ESC AMI QIs improved in both countries, and more so in the UK from 2006 to 2013. Part of the improvement in the UK could be attributed to slower adoption of guideline recommended care. In both countries, there was lower proportion of electrocardiographic ST-segment deviation at the time of admission to hospital, likely related to increased use of troponins and of higher sensitivity. In Israel, a high proportion of NSTEMI received timely coronary angiography, which may be explained by the fact that in Israel, all hospitals but one that receive patients with ACS have on-site 24-hour-7-days-a-week catheterization laboratories. For the UK, timely coronary angiography and PCI for NSTEMI and STEMI increased. This may be attributed, in part, to comprehensive tracking and auditing of clinical care, timely publications of center performance[21] and through local, regional, and national network quality improvement exercises[22]. This may also explain the improvement in QI attainment in the UK, in addition to the availability of specific treatments through the NHS. Indeed, the later adoption of DAPT in the UK compared to Israel demonstrates the influence of system decisions (e.g. approval/funding of certain drugs) in adoption and compliance with guideline recommended therapy. Going forward, Israel could, therefore, aspire to improving times to PCI for STEMI, whilst for the UK timely greater access to and timely revascularization for NSTEMI deserves greater attention. Both countries require improved assessment of LV function.

Over the study period, as adherence to guideline-indicated care improved in each country, we noted a corresponding decline in mortality. Indeed our findings are in line with earlier research from the UK[9,18] and France[13] that separately reported a

statistically significant inverse association between ESC AMI QI attainment and early and late mortality.

Despite substantial improvements in treatment and associated survival[23], global burden of AMI remains high. Recently, the ESC Atlas project highlighted major between country differences in cardiovascular health, delivery and standardized outcomes across Europe[24,25]. Earlier work found that the rates of adoption of cardiovascular health technologies such as primary PCI for STEMI vary between and within countries[26,27], and that missed opportunities in the provision of AMI guideline-indicated care were associated with excess mortality[15,28]. Notably, the importance of 'measuring to improve care' has been emphasized by organizations[1] as well as by international guidelines, and is a first necessary step in any attempt to reduce variation in cardiovascular disease. Whilst earlier research has revealed disparities in early mortality, suggested to be attributable to level of care, these studies did not map care to internationally recognized performance indices[29,30]. To our knowledge, our study is the first time that internationally recognized AMI QIs have been used to compare the levels of provision of guideline-indicated care between two countries. Thus, our investigation may serve as an example and incentive to record and report, both general patient data regarding AMI on a national and hospital level, and of QIs, in order to improve patient care and reduce the burden of disease.

Although this work has strengths, one must appreciate its limitations. Each registry has its own data definitions, mechanisms for identifying potential participants, and data recording. The GRACE and CRUSADE scores were not recorded in either registry, nor was patient satisfaction. Assessment of left ventricular systolic function

for UK participants was low, and for Israel declined, which may have reduced the available data for assessment of an eligible population for receipt of ACE-inhibitors and ß-blockers. Another weakness is the perception of causation arising from the inverse association between attainment of care and outcomes – we describe association with mortality and not causation. It is certainly possible that other factors may explain and contribute to this association such as lower risk patients receiving more treatments compared with sicker patients with an unrecorded contraindication receiving fewer. In this context, the expected reduction in mortality should be assessed according to relevant RCTs and not this investigation of care quality.

Acknowledgement

MH was funded by the Wellcome Trust as a Sir Henry Wellcome Postdoctoral Fellow (reference: 206470/Z/17/Z)

References

1 Chassin MR, Loeb JM, Schmaltz SP, et al. Accountability measures--using measurement to promote quality improvement. N Engl J Med 2010;**363**:683–8. doi:10.1056/NEJMsb1002320

2 authors no. Crossing the Quality Chasm: A New Health System for the 21st Century - PubMed - NCBI. https://www.ncbi.nlm.nih.gov/pubmed/25057539 (accessed 31 Jan 2018).

3 Lindenauer PK, Remus D, Roman S, et al. Public reporting and pay for performance in hospital quality improvement. N Engl J Med 2007;**356**:486–96. doi:10.1056/NEJMsa064964

4 Spertus JA, Bonow RO, Chan P, et al. ACCF/AHA new insights into the methodology of performance measurement: a report of the American College of Cardiology Foundation/American Heart Association Task Force on performance measures. Circulation 2010;**122**:2091–106. doi:10.1161/CIR.0b013e3181f7d78c

5 Members WC, Jneid H, Addison D, et al. 2017 AHA/ACC Clinical Performance and Quality Measures for Adults With ST-Elevation and Non–ST-Elevation Myocardial Infarction: A Report of the American College of Cardiology/American Heart Association Task Force on Performance Measures. J Am Coll Cardiol 2017;:23847. doi:10.1016/j.jacc.2017.06.032

6 Task Force on the management of ST-segment elevation acute myocardial infarction of the European Society of Cardiology (ESC), Steg PG, James SK, et al. ESC Guidelines for the management of acute myocardial infarction in patients presenting with ST-segment elevation. Eur Heart J 2012;**33**:2569–619. doi:10.1093/eurheartj/ehs215

7 Roffi M, Patrono C, Collet J-P, et al. 2015 ESC Guidelines for the management of acute coronary syndromes in patients presenting without persistent ST-segment elevation: Task Force for the Management of Acute Coronary Syndromes in Patients Presenting without Persistent ST-Segment Elevation of the European Society of Cardiology (ESC). Eur Heart J 2016;**37**:267–315. doi:10.1093/eurheartj/ehv320

8 Schiele F, Gale CP, Bonnefoy E, et al. Quality indicators for acute myocardial infarction: A position paper of the Acute Cardiovascular Care Association. Eur Heart J Acute Cardiovasc Care 2017;**6**:34–59. doi:10.1177/2048872616643053

9 Bebb O, Hall M, Fox KAA, et al. Performance of hospitals according to the ESC ACCA quality indicators and 30-day mortality for acute myocardial infarction: national cohort study using the United Kingdom Myocardial Ischaemia National Audit Project (MINAP) register. Eur Heart J Published Online First: 20 February 2017. doi:10.1093/eurheartj/ehx008

10 Schiele F, Gale CP, Simon T, et al. Assessment of Quality Indicators for Acute Myocardial Infarction in the FAST-MI (French Registry of Acute ST-Elevation or Non-ST-Elevation Myocardial Infarction) Registries. Circ Cardiovasc Qual Outcomes 2017;**10**. doi:10.1161/CIRCOUTCOMES.116.003336

11 Herrett E, Smeeth L, Walker L, et al. The Myocardial Ischaemia National Audit Project (MINAP). Heart Br Card Soc 2010;**96**:1264–7. doi:10.1136/hrt.2009.192328

12 Behar S, Battler A, Porath A, et al. A prospective national survey of management and clinical outcome of acute myocardial infarction in Israel, 2000. Isr Med Assoc J IMAJ 2003;**5**:249–54.

13 Cambou J-P, Simon T, Mulak G, et al. The French registry of Acute ST elevation or non-ST-elevation Myocardial Infarction (FAST-MI): study design and baseline characteristics. Arch Mal Coeur Vaiss 2007;**100**:524–34.

14 Jernberg T, Attebring MF, Hambraeus K, et al. The Swedish Web-system for enhancement and development of evidence-based care in heart disease evaluated according to recommended therapies (SWEDEHEART). Heart Br Card Soc 2010;**96**:1617–21. doi:10.1136/hrt.2010.198804

15 Dondo TB, Hall M, Timmis AD, et al. Excess mortality and guideline-indicated care following non-ST-elevation myocardial infarction. Eur Heart J Acute Cardiovasc Care 2017;**6**:412–20. doi:10.1177/2048872616647705

16 Peterson ED, Roe MT, Mulgund J, et al. Association between hospital process performance and outcomes among patients with acute coronary syndromes. JAMA 2006;**295**:1912–20. doi:10.1001/jama.295.16.1912

17 Gale CP, Weston C, Denaxas S, et al. Engaging with the clinical data transparency initiative: a view from the National Institute for Cardiovascular Outcomes Research (NICOR). Heart Br Card Soc 2012;**98**:1040–3. doi:10.1136/heartjnl-2012-302469

18 Simms AD, Batin PD, Weston CF, et al. An evaluation of composite indicators of hospital acute myocardial infarction care: a study of 136,392 patients from the Myocardial Ischaemia National Audit Project. Int J Cardiol 2013;**170**:81–7. doi:10.1016/j.ijcard.2013.10.027

19 Rasmussen JN, Chong A, Alter DA. Relationship between adherence to evidence-based pharmacotherapy and long-term mortality after acute myocardial infarction. JAMA 2007;**297**:177–86. doi:10.1001/jama.297.2.177

20 Wei L, Wang J, Thompson P, et al. Adherence to statin treatment and readmission of patients after myocardial infarction: a six year follow up study. Heart Br Card Soc 2002;**88**:229–33.

21 Weston C, Gavalova L, Whittaker T, et al. Myocardial Ischaemia National Audit Project. How the NHS cares for patients with heart attack: Annual Public Report April 2013–March 2014. NICOR Ed Padcreative 2014.

22 Gallagher SM, Lovell MJ, Jones DA, et al. Does a 'direct' transfer protocol reduce time to coronary angiography for patients with non-ST-elevation acute coronary syndromes? A prospective observational study. BMJ Open 2014;**4**:e005525. doi:10.1136/bmjopen-2014-005525

23 Hall M, Dondo TB, Yan AT, et al. Association of Clinical Factors and Therapeutic Strategies With Improvements in Survival Following Non-ST-Elevation Myocardial Infarction, 2003-2013. JAMA 2016;**316**:1073–82. doi:10.1001/jama.2016.10766

24 Atlas Writing Group, Timmis A, Townsend N, et al. European Society of Cardiology: Cardiovascular Disease Statistics 2017. Eur Heart J Published Online First: 27 November 2017. doi:10.1093/eurheartj/ehx628

25 Timmis A, Gale CP, Flather M, et al. Cardiovascular disease statistics from the European atlas: inequalities between high- and middle-income member countries of the ESC. Eur Heart J Qual Care Clin Outcomes 2018;**4**:1–3. doi:10.1093/ehjqcco/qcx045

26 Hall M, Laut K, Dondo TB, et al. Patient and hospital determinants of primary percutaneous coronary intervention in England, 2003–2013. Heart 2016;:heartjnl-2015-308616. doi:10.1136/heartjnl-2015-308616

27 Laut KG, Gale CP, Pedersen AB, et al. Persistent geographical disparities in the use of primary percutaneous coronary intervention in 120 European regions: exploring the variation. EuroIntervention J Eur Collab Work Group Interv Cardiol Eur Soc Cardiol 2013;**9**:469–76. doi:10.4244/EIJV9I4A76

28 Dondo TB, Hall M, Timmis AD, et al. Geographic variation in the treatment of non-ST-segment myocardial infarction in the English National Health Service: a cohort study. BMJ Open 2016;**6**:e011600. doi:10.1136/bmjopen-2016-011600

29 McNamara RL, Chung SC, Jernberg T, et al. International comparisons of the management of patients with non-ST segment elevation acute myocardial infarction in the United Kingdom, Sweden, and the United States: The MINAP/NICOR, SWEDEHEART/RIKS-HIA, and ACTION Registry-GWTG/NCDR registries. Int J Cardiol 2014;**175**:240–7. doi:10.1016/j.ijcard.2014.04.270

30 Chung S-C, Gedeborg R, Nicholas O, et al. Acute myocardial infarction: a comparison of short-term survival in national outcome registries in Sweden and the UK. Lancet Lond Engl 2014;**383**:1305–12. doi:10.1016/S0140-6736(13)62070-X

Figure 1 – Flow diagram

Figure 2 - Temporal changes in baseline ischemic risk (GRACE risk score) from 2006 to 2013 for non-ST and ST segment elevation myocardial infarction, and both.

Figure 3 – Proportion of quality indicator adherence by registry and year

ACEi – Angiotensin converting enzyme inhibitor, ARB- angiotensin receptor blocker, BB-Beta blockers, NSTEMI: non-ST segment elevation myocardial infarction; STEMI: ST segment elevation myocardial infarction

Table 1- Baseline and treatment characteristics

	Israel				UK			
	Total cohort	Years			Total cohort	Years		
	(n=4761)	2006 (n=1731)	2010 (n=1539)	2013 (n=1491)	(n=17,608)	2006 (n=5,171)	2010 (n=6,765)	2013 (n=5,672)
Demographics								
Age in years, mean (SD)	63.8 (13.1)	63.5 (13.3)	63.6 (12.9)	64.1 (13.0)	69.3 (13.9)	70.0 (13.6)	68.9 (14.0)	69.1 (14.1)
Age in years, median (IQR)	63 (54.0-74.0)	63 (53.0-74.0)	63 (54.0-73.0)	64 (55.0-74.0)	70.5 (59.0-80.3)	71.6 (59.0-80.6)	70.0 (59.0-80.0)	70.0 (58.3-80.4)
Female	1059 (22.2)	384 (22.2)	328 (22.0)	347 (22.5)	5954 (33.9)	1818 (35.3)	2240 (33.1)	1896 (33.5)
Medical history								
Prior myocardial infarction	1366 (28.7)	469 (27.1)	448 (30.0)	449 (29.2)	6068 (34.5)	1882 (36.4)	2351 (34.8)	1835 (32.4)*
Hypertension	2946 (61.9)	986 (57.1)	960 (64.4)	1000 (65.0)*	8120 (49.5)	2388 (48.5)	3084 (49.9)	2648 (50.0)
Diabetes	1725 (36.3)	559 (32.3)	556 (37.3)	610 (39.6)*	3290 (19.6)	881 (19.9)	1282 (19.9)	1127 (20.7)
Dyslipidaemia	3309 (69.5)	1076 (62.3)	1093 (73.3)	1140 (74.1)*	5273 (33.0)	1451 (30.9)	2091 (34.5)	1731 (33.2)*
Family history of IHD	1213 (25.5)	414 (24.0)	417 (28.0)	382 (24.8)*	4192 (31.3)	1186 (33.0)	1688 (32.4)	1318 (28.8)*

Smoker (current or previous)	2941 (62.5)	1064 (62.4)	948 (64.7)	929 (60.4)	10159 (62.9)	2990 (64.7)	3916 (62.8)	3253 (61.4)*
Peripheral vascular disease	429 (9.0)	175 (10.1)	132 (8.9)	122 (7.9)*	700 (4.4)	220 (4.6)	261 (4.3)	219 (4.2)
Heart failure	405 (8.5)	149 (8.6)	134 (9.0)	122 (7.9)	837 (5.2)	256 (5.4)	315 (5.1)	266 (5.1)
Chronic kidney disease	612 (12.9)	221 (12.8)	181 (12.1)	210 (13.6)*	897 (5.6)	171 (3.6)	386 (6.3)	340 (6.5)*
Cerebrovascular disease	400 (8.4)	156 (9.0)	119 (8.0)	125 (8.1)*	1375 (8.5)	447 (9.4)	518 (8.5)	410 (7.8)*
Clinical Presentation								
Out of hospital cardiac arrest	160 (3.4)	58 (3.4)	42 (2.8)	60 (3.9)	371 (2.2)	83 (1.7)	131 (2.0)	157 (2.9)*
ST deviation on admission	3323 (69.8)	1260 (72.9)	1051 (70.5)	1012 (65.8)*	9203 (55.0)	2824 (58.7)	3410 (53.1)	2969 (53.8)*
Killip class								
I	3946 (84.0)	1384 (80.1)	1273 (85.4)	1289 (87.2)*	3301 (79.4)	Not available	2 (66.7)	3299 (79.4)
II	424 (9.0)	199 (11.5)	115 (7.7)	110 (7.4)*	571 (13.7)		0 (0)	571 (13.8)
III	239 (5.1)	115 (6.7)	71 (4.8)	53 (3.6)*	226 (5.4)		1 (33.3)	225 (5.4)
IV	89 (1.9)	30 (1.7)	32 (2.1)	27 (1.8)	59 (1.4)		0 (0)	59 (1.4)

GRACE score, mean (SD)	110.5 (34.0)	111.9 (35.2)	109.4 (33.9)	110.2 (32.9)	121.0 (34.4)	123.6 (31.6)	120.8 (34.7)	121.1 (34.2)
GRACE STEMI, mean (SD)	96.6 (29.3)	97.5 (30.6)	96.9 (29.7)	95.5 (27.5)	122.4 (33.6)	137.1 (31.2)	122.7 (33.8)	121.9 (33.3)
GRACE NSTEMI, mean (SD)	123.1 (33.1)	123.9 (34.4)	122.4 (33.0)	122.8 (31.9)	120.2 (34.8)	117.9 (30.3)	119.9 (35.0)	120.7 (34.6)
Low risk GRACE category	2050 (51.7)	660 (50.8)	720 (53.2)	670 (50.9)	3913 (43.9)	23 (40.4)	2062 (43.7)	1828 (44.2)
Medium risk GRACE category	1078 (27.2)	352 (27.1)	353 (26.1)	373 (28.3)	2665 (29.9)	21 (36.8)	1421 (30.1)	1223 (29.5)
High risk GRACE category	782 (19.72)	277 (21.5)	261 (19.6)	244 (19.0)	2341 (26.3)	13 (22.8)	1239 (26.2)	1089 (26.3)
In-hospital revascularisation								
Coronary angiography†	4168 (87.6)	1439 (83.3)	1349 (90.5)	1380 (89.7)*	10218 (64.8)	1926 (37.3)	4316 (72.7)	3976 (85.5)*
PCI	3344 (70.3)	1135 (65.7)	1086 (72.8)	1123 (73.0)*	6325 (41.0)	711 (14.4)	2776 (52.5)	2838 (66.0)*
CABG surgery	254 (5.3)	106 (6.1)	64 (4.3)	84 (5.5)	321 (2.0)	75 (1.5)	149 (2.5)	97 (2.1)*
Medications at discharge								
Aspirin	4460 (93.7)	1606 (92.8)	1405 (94.2)	1449 (94.2)	12634 (89.1)	3635 (81.4)	4853 (91.2)	4146 (94.4)*
$P2Y_{12}$ inhibitor	3871 (81.3)	1279 (73.9)	1269 (85.1)	1323 (86.0)*	8762 (62.4)	51 (1.1)	4731 (91.4)	3980 (94.9)*

β-blocker	3782 (79.4)	1387 (80.1)	1201 (80.5)	1194 (77.6)	11166 (86.5)	2916 (73.7)	4,396 (90.3)	3854 (94.3)*
Statin	4458 (93.6)	1589 (91.8)	1439 (96.5)	1430 (92.9)	13079 (90.9)	3916 (85.4)	4990 (92.7)	4173 (94.4)*
ACEi/ARB	3625 (76.1)	1261 (72.8)	1184 (79.4)	1180 (76.7)*	11436 (84.7)	3210 (74.2)	4486 (88.7)	3740 (91.0)*

Values are presented as n (%) unless otherwise stated.

ACEi – Angiotensin converting enzyme inhibitor, ARB- angiotensin receptor blocker, IHD- ischaemic heart disease.

IQR- interquartile range, SD- standard deviation, PCI- percutaneous coronary intervention

*** Denotes p<0.05 compared to 2006.**

Table 2 – Quality indicators according to year and country

		Israel			United Kingdom		
QI	**QI Type**	**Cohort 1**	**Cohort 2**	**Cohort 3**	**Cohort 1**	**Cohort 2**	**Cohort 3**
		2006 (n=1731)	2010 (n=1539)	2013 (n=1491)	2006 (n=5,171)	2010 (n=6,765)	2013 (n=5,672)
2.1: Proportion reperfused within 12 hours (STEMI)	Main	581 (96.2)	555 (96.0)	595 (95.0)	1141 (84.6)	1492 (90.8)	1405 (91.7)*
2.2: STEMI timely reperfusion	Main	236 (42.1)	299 (56.6)	294 (54.0)*	600 (50.6)	1017 (60.6)	1133 (72.3)*
2.2a: fibrinolysis (<30 minutes)		19 (14.6)	7 (46.7)	10 (71.4)*	595 (50.6)	214 (52.2)	22 (45.8)
2.2b: Primary PCI (<60 minutes)		213 (50.5)	214 (56.9)	246 (53.6)	5 (50.0)	803 (66.3)	1111 (74.9)
2.3: NSTEMI	Main	334 (59.4)	416 (81.2)	506 (78.1)*	79 (37.4)	292 (53.0)	358 (57.9)*

angiography <72 hours							
2.3: NSTEMI angiography <72 hours (no HR features)	Main	227 (67.0)	295 (87.5)	341 (83.8)*	224 (41.7)	742 (58.9)	820 (64.1)*
2.4: arterial access (STEMI), minutes (median, IQR)	Secondary	70.3 (43-115)	66.5 (39-111)	67.0 (35-107)	80.4 (30-165)	46.2 (31-71)	40.2 (29-60)*
3.3: Assessment of LV function recorded in notes	Main	1522 (87.9)	1181 (79.2)	1112 (72.3)*	1111 (22.1)	2550 (40.0)	2731 (50.1)*
4.1: Proportion with adequate	Main	1279 (77.3)	1269 (86.5)	1323 (86.3)*	51 (1.1)	4731 (91.4)	3980 (94.9)*

$P2Y_{12}$ inhibition on discharge							
4.2: Proportion NSTEMI getting fondaparinux	Main	0 (0)	0 (0)	46 (2.4)	0 (0)	562 (14.5)	1549 (49.5)*
4.3: Proportion discharged on DAPT	Secondary	1255 (72.2)	1242 (83.0)	1294 (83.4)*	47 (1.1)	4,477 (88.9)	3,819 (93.5)*
5.1: Proportion discharged with statins	Main	1589 (92.4)	1439 (96.6)	1430 (93.0)	3916 (85.4)	4990 (92.7)	4173 (94.4)*
5.2: ACEI/ARB in those with HF or EF $\leq$40	Secondary	232 (83.1)	189 (84.9)	160 (82.9)	1024 (77.3)	1473 (89.1)	1416 (92.0)*

5.3: β- blocker in those with HF or EF ≤40	Secondary	239 (85.0)	194 (88.8)	158 (81.9)	845 (72.7)	1469 (91.9)	1499 (96.8)
7.1: Main Composite QI (opportunity-based)		86.8	88.2	85.9	46.2	74.7	80.0*
7.2: Composite QI (all or none, overall score)		70.2	81.4	78.0*	1.0	81.6	85.8*
7.2a: Composite QI (all or none, 3 measures)[1] , %		73.5	83.2	79.7*	51.0	88.2	93.0*
7.2b: Composite		54.0	70.9	65.5*	1.1	83.3	88.9*

QI (all or none, 5 measures)[1] , %							
7.3 Mortality at 30-days adjusted for GRACE		5.1	4.7	4.2*	8.1	7.7	7.6*
Crude mortality rate at 30-days		5.3	5	3.8*	11.0	7.5	7.8*
Crude mortality at 1 year		10.9	9.5	8.6	22.0	16.4	10.1

ACEI: angiotensin-converting enzyme inhibitors; ARB: angiotensin receptor blocker; DAPT- dual anti-platelet therapy; EF: ejection fraction; LV: left ventricle; NSTEMI: non-ST segment elevation myocardial infarction; PCI: percutaneous coronary intervention; QI- quality indicator; STEMI: ST segment elevation myocardial infarction